TRIHALOMETHANE AND NONPURGEABLE TOTAL ORGANIC-HALIDE FORMATION POTENTIALS FOR THE MISSISSIPPI RIVER AND SOME OF ITS TRIBUTARIES, MARCH-APRIL 1992

By R.E. Rathbun

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CONVERSION FACTORS

Multiply	By	To obtain
nanometer (nm)	3.937×10^{-8}	inch
micrometer (µm)	3.937×10^{-5}	inch
millimeter (mm)	3.937×10^{-2}	inch
meter (m)	3.937×10^{1}	inch
kilometer (km)	0.6214	mile
microgram per liter (µg/L)	6.243×10^{-8}	pound per cubic foot
milligram per liter (mg/L)	6.243×10^{-5}	pound per cubic foot
microliter (µL)	3.531×10^{-8}	cubic foot
milliliter (mL)	3.531×10^{-5}	cubic foot
liter (L)	3.531×10^{-2}	cubic foot
cubic meter per second (m^3/s)	3.531×10^{1}	cubic foot per second

Temperature in degree Celsius (°C) may be converted to degree Fahrenheit (°F) using:

$$°F = °C(1.8) + 32.0$$

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R.E. Rathbun

ABSTRACT

Trihalomethane and nonpurgeable total organic-halide formation potentials were determined for the Mississippi River and some of its tributaries from water samples collected between March 25 and April 6, 1992. Formation potentials were measured for 12 sites along the Mississippi River between Minneapolis, Minnesota, and New Orleans, Louisiana, and for the Missouri and Ohio Rivers at sites 1.6 kilometers upstream from their confluences with the Mississippi River. Formation potentials were determined as a function of initial pH and initial free-chlorine concentration for one reaction time of 168.0 hours at a temperature of 25 degrees Celsius. The formation potentials also were determined as a function of reaction time over a 168.0-hour period for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter. Ancillary measurements include determinations of pH as a function of reaction time, pH values at the end of the formation-potential experiments, dissolved organic-carbon and bromide concentrations, ultraviolet absorbances, and specific conductances. All experiments except the reaction-time experiments were done in duplicate, thus permitting an analysis of the errors involved in determining the trihalomethane and nonpurgeable total organic-halide formation potentials. Results of the formation-potential determinations, the ancillary measurements, and the error analysis are listed in tables.

INTRODUCTION

The Mississippi River begins in Lake Itasca in north-central Minnesota and drains into the Gulf of Mexico, 3,720 km downstream at a point in Louisiana called Head of Passes. The river flows through Minnesota and Louisiana and forms parts of the borders of Wisconsin, Iowa, Illinois, Missouri, Kentucky, Tennessee, Arkansas, and Mississippi. Numerous cities, towns, and villages in these States use the Mississippi River as a source of drinking water. Other population centers along the river might begin to use the Mississippi River as a source of drinking water as ground-water supplies are depleted and as the population increases.

To make water from the Mississippi River safe for drinking, the water first must be disinfected, usually with free chlorine, to eliminate the possibility of the transmission of water-borne diseases such as typhoid fever. Research (Rook, 1974; Bellar and others, 1974; Fleischacker and Randtke, 1983; and Johnson and Jensen, 1986) has indicated, however, that chlorination of natural waters results in the formation of various byproducts, some of which may be health hazards. Therefore, the potential for the formation of these byproducts must be considered when the Mississippi River is used as a source of drinking water.

These byproduct compounds are divided into two classes. The first class consists of the trihalomethane (THM) compounds, which are chlorinated and brominated derivatives of methane. The four compounds commonly included in this class are chloroform, bromodichloromethane, chlorodibromomethane, and bromoform. These compounds are volatile and can be determined by gas chromatography techniques. The second class consists of chlorinated and brominated compounds with molecular weights higher than those of the THM compounds. Compounds in this second class are more polar and generally are nonvolatile. They are more difficult to determine as individual compounds; consequently, they commonly are determined together as a bulk parameter called the total organic-halide (TOX) concentration. Because this measurement also includes the THM compounds, the samples usually are purged with an inert gas before analysis to remove the volatile THM compounds. This procedure results in the nonpurgeable total organic-halide (NPTOX) concentration.

The U.S. Geological Survey Mississippi River project is a multidisciplinary study of the water-quality characteristics of the river. Specific topics of study include the distribution of agricultural pesticides and herbicides, trace metals, and industrial organic chemicals among the water, sediment, and biotic phases of the river system and how these substances are transported by the river. Also of interest are the water-quality characteristics of the Mississippi River related to its use as a source of drinking water. Water characteristics affecting this use include constituents already present in the water as well as constituents that are formed when the water is chlorinated to make it safe for drinking. The objective of this report is to describe the results of the determination of disinfection byproducts that could be formed when water from the Mississippi River is chlorinated.

Purpose and Scope

This report presents the results of the determination of THM and NPTOX formation potentials for the Mississippi River and some of its tributaries. Formation potentials for the THM and NPTOX compounds are defined as the concentrations of these compounds that are formed when water samples are chlorinated at specific conditions of pH, free-chlorine concentration, reaction time, and temperature. In this study, formation potentials were determined for water from 12 sites along the Mississippi River between Minneapolis, Minn., and New Orleans, La., and for water from the Missouri and Ohio Rivers at sites 1.6 km upstream from their confluences with the Mississippi River. Water samples were collected between March 25, 1992, and April 6, 1992. Formation potentials were determined as a function of initial pH and initial free-chlorine concentration for one reaction time of 168.0 hours at a temperature of 25°C. Also, the formation potentials were determined as a function of reaction time over a 168.0-hour period for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 mg/L.

Acknowledgments

Water samples upon which this work was based were collected as a part of the U.S. Geological Survey Mississippi River project under the direction of R.H. Meade. J.A. Moody provided logistical support. Wayne Simoneaux and Bob Cutting piloted the research vessel ACADIANA, and Jean Hough was the cook. L.B. Barber, II, W.L. Campbell, Lesly Conaway, Don Kelly, T.I. Noyes, John Sullivan, and Charles Tabor assisted with the sampling. J.A. Moody and G.S. Ellis collected the Minneapolis, Minn., sample. Appreciation is expressed to all who helped with this study.

PROCEDURE FOR DETERMINATION OF TRIHALOMETHANE AND NONPURGEABLE TOTAL ORGANIC-HALIDE FORMATION POTENTIALS

Sampling Procedure

The 17-m research vessel ACADIANA, owned and operated by the Louisiana Universities Marine Consortium, was used for collecting samples. Grab samples of water were collected by dropping a stainless-steel bucket off the port side of the vessel. The bucket was rinsed once with river water before collecting the sample. Single samples usually were collected from the midpoint of the navigation channel. One exception was the Ohio River, where there was a question about whether the various tributaries flowing into the Ohio River would be mixed at the sampling location. Consequently, a composite sample of equal volumes was collected from points located at 0.1, 0.5, and 0.9 of the width measured from the left edge of the water.

On the Mississippi River, the sampling locations generally were slightly upstream from metropolitan areas. General locations in terms of the metropolitan area and specific locations in terms of cumulative river kilometers upstream from Head of Passes, La., for the sampling sites, dates and times of sample collection, and water discharges at the sampling times are listed in table 1. Location of the sampling sites is shown in figure 1.

Table 1.--General location and cumulative river kilometers upstream from Head of Passes, La., for the sampling sites, dates and times of sampling, and water discharges

[m^3/s, cubic meters per second]

General location	Cumulative river kilometers	Date	Time (hours)	Water discharge[1] (m^3/s)
Minneapolis, Minn.	2,915.2	04-06-92	1030	310
LaCrosse, Wis.	2,666.9	04-03-92	1229	1,900
Dubuque, Iowa	2,470.7	04-02-92	2046	2,700
Davenport, Iowa	2,324.6	04-02-92	1031	2,600
Quincy, Ill.	2,068.4	04-01-92	1241	3,600
Missouri River[2]	1,850.8	03-31-92	1554	2,100
St. Louis, Mo.	1,825.1	03-31-92	1403	7,800
Cairo, Ill.	1,553.6	03-30-92	1422	8,000
Ohio River[2]	1,536.5	03-30-92	1252	8,900
Memphis, Tenn.	1,194.1	03-29-92	0640	23,100
Greenville, Miss.	877.1	03-28-92	0009	26,400
Natchez, Miss.	597.4	03-26-92	2252	25,300
Baton Rouge, La.	386.7	03-26-92	0536	22,200
New Orleans, La.	169.3	03-25-92	0906	22,300

[1] Discharge data from Moody (in press).

[2] Sampling site 1.6 kilometers upstream from confluence with Mississippi River.

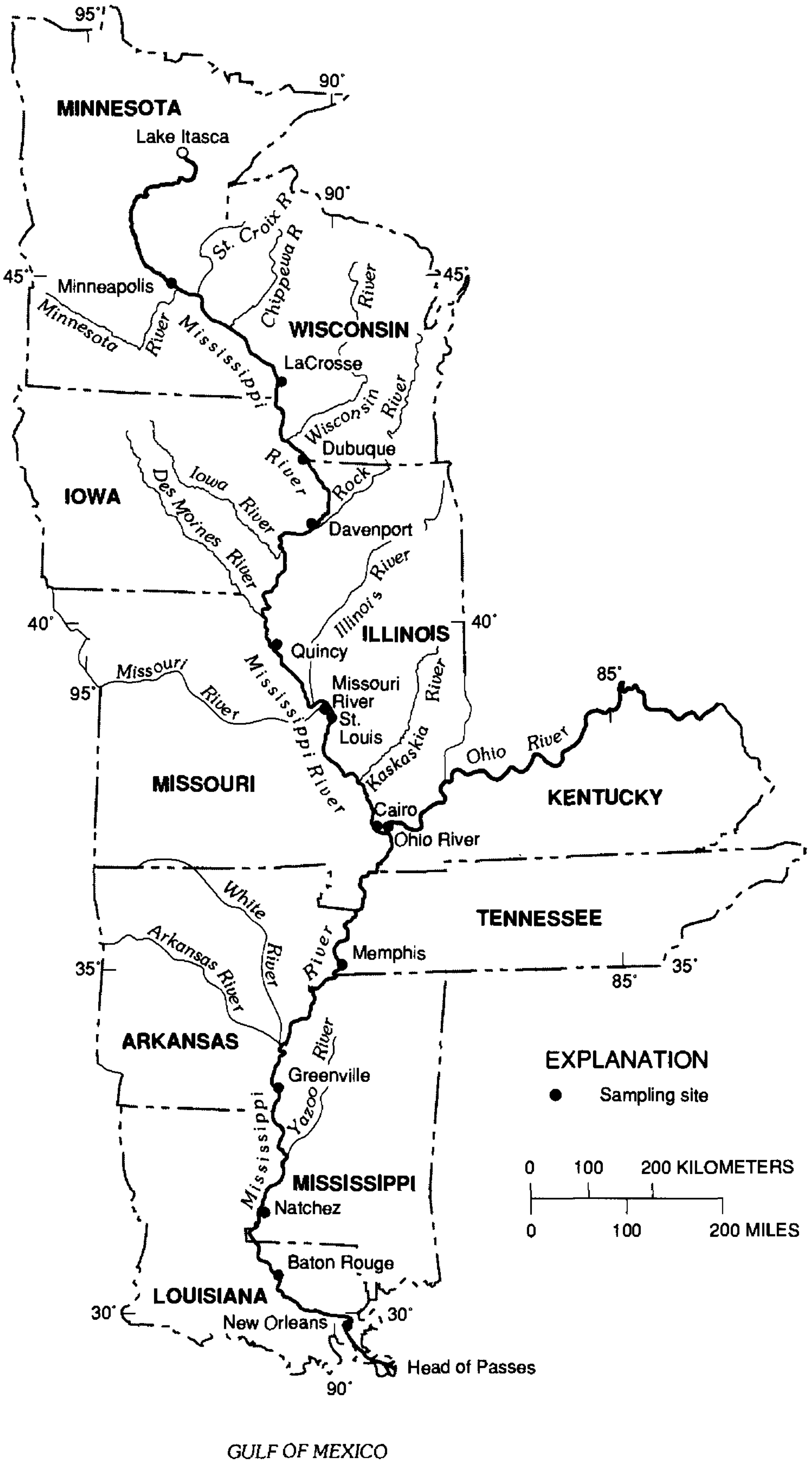

Figure 1.--Location of sampling sites in the Mississippi River basin.

The water sample collected at each site was transferred from the bucket to a stainless-steel reservoir for pressure filtration. The water was filtered through low-extractable 0.45-µm membrane filters that were prerinsed with about 2 L of high-purity water from a Barnstead Nanopure water system. The first 600 mL of sample water through the filter was discarded. The water collected at each site was filtered into six 1-L amber glass bottles with Teflon-lined caps. The sample bottles were chilled with ice until shipment to the laboratory in Arvada, Colo. Shipment was by overnight air freight in insulated coolers containing refrigerant cold packs. Water samples in the laboratory were stored at 4°C until the formation-potential experiments were done.

Formation-Potential Experiments

The formation potentials for the THM and NPTOX compounds were determined as a function of initial pH and initial free-chlorine concentration at 25°C for a reaction time of 168.0 hours. Initial pH values of 5.50, 7.50, and 10.00 and initial free-chlorine concentrations of 15.0, 30.0, and 50.0 mg/L were used, giving nine THM and nine NPTOX formation potentials for each water sample. These large initial free-chlorine concentrations were used to satisfy any initial chlorine demand of the water sample and to ensure a residual free-chlorine concentration at the end of the 168.0-hour reaction time. The 168.0-hour reaction time was used to cover the maximum possible time water might be in a distribution system before use. Formation potentials also were determined as a function of time during the 168.0-hour period for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 mg/L.

The formation-potential experiments were done in 40-mL amber glass vials with Teflon-faced septum caps. Initiation of an experiment consisted of adjusting the pH of the water sample to the desired initial pH using 0.1 normal and 1.0 normal sulfuric acid and sodium hydroxide. The desired initial free-chlorine concentration was obtained by adding the appropriate volume of a reagent-grade sodium hypochlorite solution. The free-chlorine concentration of this solution was determined prior to the start of each experiment by using an amperometric titration procedure. Blank samples of each water sample were taken before the addition of the sodium hypochlorite solution.

Sample vials were filled completely so that no head space existed. Vials were placed in an incubator at 25°C. All 168.0-hour experiments were done with duplicate vials. At the end of 168.0 hours, the experiments were terminated by quenching the remaining free chlorine with a sodium thiosulfate solution for the THM experiments and sodium sulfite crystals for the NPTOX experiments. For the reaction-time experiments, samples were quenched at approximate times of 0, 2, 6, 12, 24, 48, 72, 120, and 168.0 hours.

Before quenching the NPTOX samples, 5.0 mL of sample was removed from each of the vials and used to estimate the residual free-chlorine concentrations. Because a precise determination of the residual free-chlorine concentration was not needed, a Hach chlorine test kit with a range from 0 to 3.5 mg/L with 0.1-mg/L divisions was used for this purpose. After acidification to a pH of about 2 with nitric acid, the NPTOX samples were purged for 10 minutes with ultrahigh-purity nitrogen gas to remove the THM compounds. Samples were stored in an incubator at 4°C until analysis.

Analysis of Trihalomethane Samples

Concentrations of the THM compounds in the samples were determined using a solvent-extraction procedure (Federal Register, 1979) with pentane as the solvent. The procedure was modified slightly in that the sample extractions were done directly in the sample vials to avoid having to transfer a sample containing volatile constituents. The procedure consisted of removing 4.5 mL of sample with an adjustable pipetter and discarding, adding 4.0 mL of pentane with a Class A pipet, and shaking the mixture for 1.5 minutes The precise amounts of sample removed and pentane added were determined by weighing the vials after each step. The Burdick and Jackson brand of pentane especially formulated for THM analyses was used. The vials containing the water and pentane layers were stored upside down at 4°C until analysis. Storing the samples upside down precluded any loss of the pentane or the THM compounds from the sample vial during storage.

The pentane extracts were analyzed with a Hewlett-Packard 5880-A gas chromatograph equipped with an electron-capture detector. A 12-m long by 0.2-mm inside diameter Hewlett-Packard, cross-linked, methyl silicone-gum capillary column with a 0.33 µm film thickness was used with the purged splitless technique. Retention times on this column were 0.92, 1.42, 2.49, and 4.77 minutes for chloroform, bromodichloromethane, chlorodibromomethane, and bromoform, respectively.

Volumes of the 40-mL sample vials were not precisely 40.0 mL and were not consistent. To adjust for variations in the vial volumes, the vials were weighed at each step of the extraction process, beginning with the empty vial and ending with the final sample/pentane step. These weights permitted determination of the exact water/pentane volume ratio for each sample. The peak areas for each sample were adjusted from the volume ratio of that sample to the average volume ratio for the standard samples for that particular run. This procedure resulted in all samples and standards being adjusted to a single water/pentane ratio.

Standard samples of known concentrations of each of the four THM compounds were prepared according to an established procedure (Federal Register, 1979). The procedure consists of adding each of the four THM compounds to methanol in a 10-mL volumetric flask. The amount added was determined approximately by volume and precisely by weighing on a five-place analytical balance. Two additional primary standards were prepared by serial dilution of this standard using gas-tight syringes. Secondary standards covering the expected range of sample concentrations were prepared by injecting microliter quantities of the primary standards into river water contained in 40-mL septum vials. River water was used to prepare the standards to eliminate any possible effect of the water chemistry on the efficiency of the extraction procedure. These secondary standards were treated exactly as the samples from the experiments except that sodium hypochlorite was not added to the standards. A new set of standards was prepared for each river-water sample.

A large number of standards was necessary because the response of the electron-capture detector was somewhat nonlinear and the standards had to cover a wide range of concentrations so that the peak areas of each of the four THM compounds in every sample were bracketed by the peak areas of the standards. The number of standards ranged from 14 for the Minneapolis sample to 10 for the New Orleans sample. These standards were analyzed twice each day, resulting in 44 to 60 percent of the samples analyzed each day being standards.

Analysis of Nonpurgeable Total Organic-Halide Samples

Concentrations of the NPTOX compounds in the samples were determined using a Dohrmann DX-20A TOX analyzer with an AD-3 adsorption module. This procedure involved adsorption of the organic compounds from the water sample onto granular activated carbon packed in glass columns. Two of these columns were used in series for each sample. Following adsorption of the sample, the contents of the columns were washed with 2 mL of a 0.08 normal potassium nitrate solution to remove inorganic halides. The granular activated carbon then was removed from the columns with a push rod into the quartz sample boat of the instrument. The analysis was started by moving the sample boat into the furnace at 800°C where the chlorinated and brominated compounds were volatilized and converted in the presence of oxygen to an equivalent amount of hydrogen halides. These ions were titrated in a microcoulometric cell, resulting in the determination of the mass of NPTOX compounds in the original sample. The NPTOX concentration was computed from this mass and the volume of sample sorbed in the adsorption step.

The high concentrations of NPTOX compounds resulting from the formation-potential experiments required dilution of the samples to assure that the concentrations were within the response range of the instrument. Samples were diluted with high-purity water from a Barnstead Nanopure system. A blank for this dilution water was analyzed each day samples were run. Usually, a 30-mL mixture was prepared, with the sample amount ranging from 5 to 25 mL, depending on the expected concentration. Ultrahigh-purity nitrogen gas was used to force 25 mL of this 30-mL sample through the glass columns containing the granular activated carbon. All aliquots were measured with Class A pipets.

Operation of the microcoulometric cell was verified at the beginning of each day by injections of a sodium chloride standard directly into the electrolyte of the cell. These verifications also were done any time during the day when it became necessary to change the cell electrolyte. Recovery of the instrument was checked at the beginning of each day by injections of a trichlorophenol standard onto granular activated-carbon ash in the instrument boat and subsequent analysis of the trichlorophenol standard. These recovery checks also were repeated any time during the day when it became necessary to change the cell electrolyte and on any other occasion when operation of the instrument might be questionable. If results of these checks deviated by more than 10 percent from the expected values, steps were taken to improve the performance of the instrument by changing the cell electrolyte and the inlet and exit tube liners and by cleaning the hatch area.

Determination of pH

The pH values of the natural water samples ranged from about 7.8 to about 8.2. For the formation potential experiments, the pH was adjusted to initial pH values of 5.50, 7.50, and 10.00. Because these water samples were not buffered, the pH of the 5.50 and 7.50 water samples increased, and the pH of the 10.00 water samples decreased slightly when the basic sodium hypochlorite solution was added to provide the free-chlorine concentration. To determine the variation of the pH with time, the pH values of each of the nine combinations of initial pH and initial free-chlorine concentration were determined at reaction times of approximately 0, 24, 48, 72, 120, 144, and 168 hours.

Measurements were made using an Orion Model 811 pH meter with a 91–02 research-grade pH probe. These samples were prepared at the same time the vials for the formation-potential experiments were filled. Amber glass bottles having Teflon-lined caps, a volume of 70 mL, and a mouth wide enough to accommodate the pH and temperature probes of the instrument were used for this purpose. The pH meter was calibrated each day before the measurements were done. A two-point calibration using buffers of 6.86 and 10.00 bracketed all the experimental pH values.

The pH values of the THM formation-potential experiments also were determined after completion of the gas chromatographic analyses. The pentane was evaporated, and the pH of the remaining water was determined for each of the nine samples.

Determination of Dissolved Organic-Carbon and Bromide Concentrations

Dissolved organic-carbon (DOC) and bromide concentrations of the water samples were determined at the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo. DOC concentration was determined using the wet-oxidation method (Wershaw and others, 1987). Bromide concentrations were determined using segmented-flow automated colorimetry (Fishman and Friedman, 1989).

Determination of Specific Conductances

Specific conductances of the sample waters were measured using a Yellow Springs Instrument Company model 32 conductance meter. Temperatures of the water samples were adjusted to 25.0°C so that no temperature corrections were necessary.

Determination of Ultraviolet Absorbances

The ultraviolet (UV) absorbance of natural waters has been used as a predictor of the DOC concentration. Various UV wavelengths have been used (Buffle and others, 1978; Oliver and Thurman, 1981; Edzwald and others, 1985; Ceraso, 1987; Chadick and Amy, 1987; Moore, 1987). UV absorbances of the water samples were determined at wavelengths of 254, 280, 330, and 400 nm. A Spectronics model 2000 spectrophotometer with a 50-mm cell was used for these determinations. Absorbances were measured for both the pH-adjusted water samples and the natural water samples.

RESULTS OF SAMPLE COLLECTION AND FORMATION-POTENTIAL EXPERIMENTS

Trihalomethane and Nonpurgeable Total Organic-Halide Formation Potentials

The potentials for formation of THM and NPTOX compounds when the water samples were treated with free chlorine are expressed as the concentrations of these compounds formed in the experiments. Two types of results were obtained. The first type consisted of concentrations of the THM and NPTOX compounds formed during a reaction time of 168.0 hours for nine combinations of initial pH and initial free-chlorine concentration. The second type consisted of concentrations of the THM and NPTOX compounds formed as a function of time during the reaction time of 168.0 hours for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 mg/L. Typical results of the first type (fig. 2) show THM and NPTOX concentrations for an initial pH of 10.00 and an initial free-chlorine concentration of 30.0 mg/L as a function of cumulative river kilometers upstream from Head of Passes, La. The DOC concentrations also are shown in figure 2. Typical results of the second type (fig. 3) show THM and NPTOX concentrations for several sampling sites along the Mississippi River as a function of reaction time.

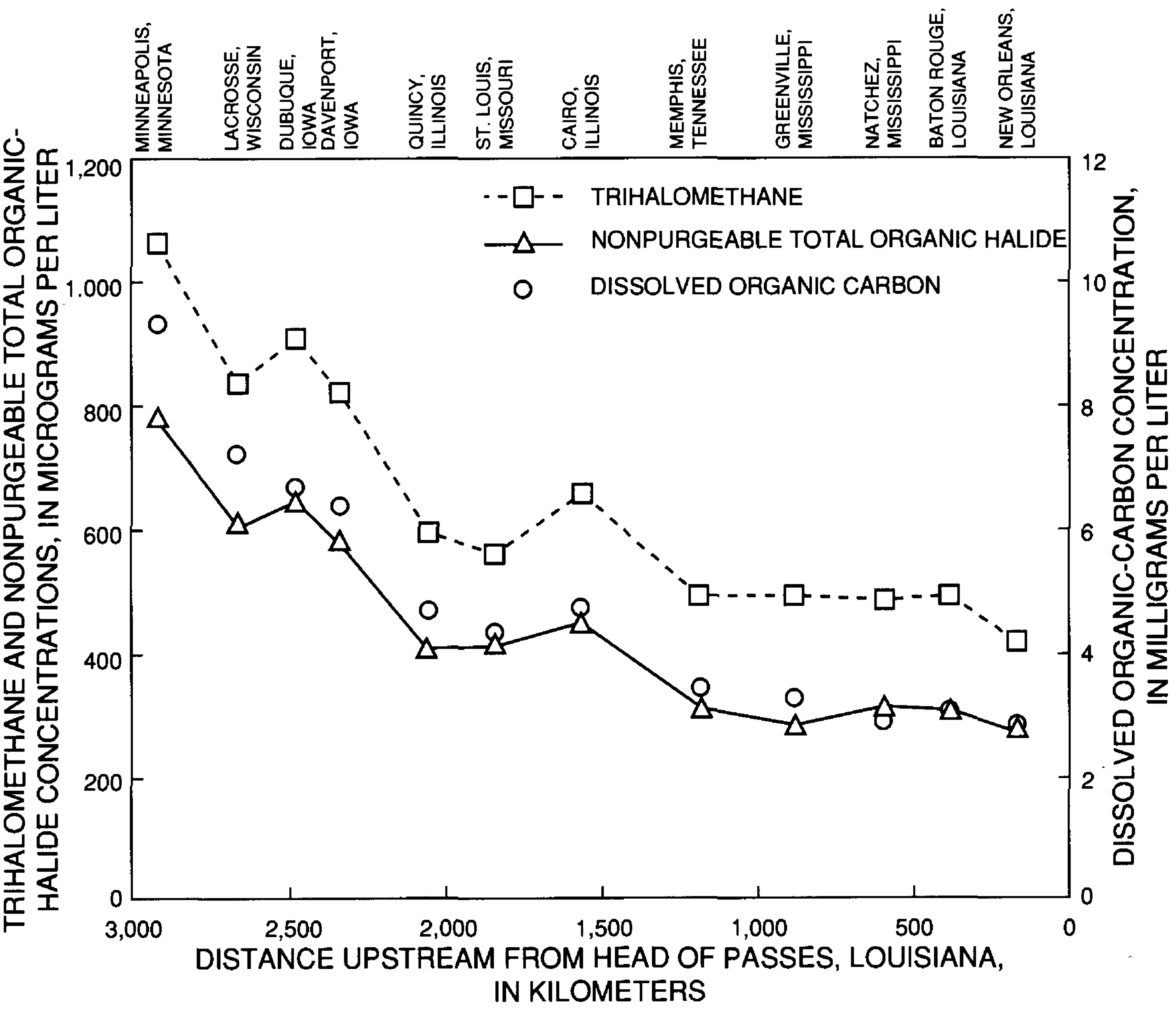

Figure 2.--Trihalomethane, nonpurgeable total organic-halide, and dissolved organic-carbon concentrations as a function of cumulative river kilometers upstream from Head of Passes, La.; initial pH of 10.00 and initial free-chlorine concentration of 30.0 milligrams per liter.

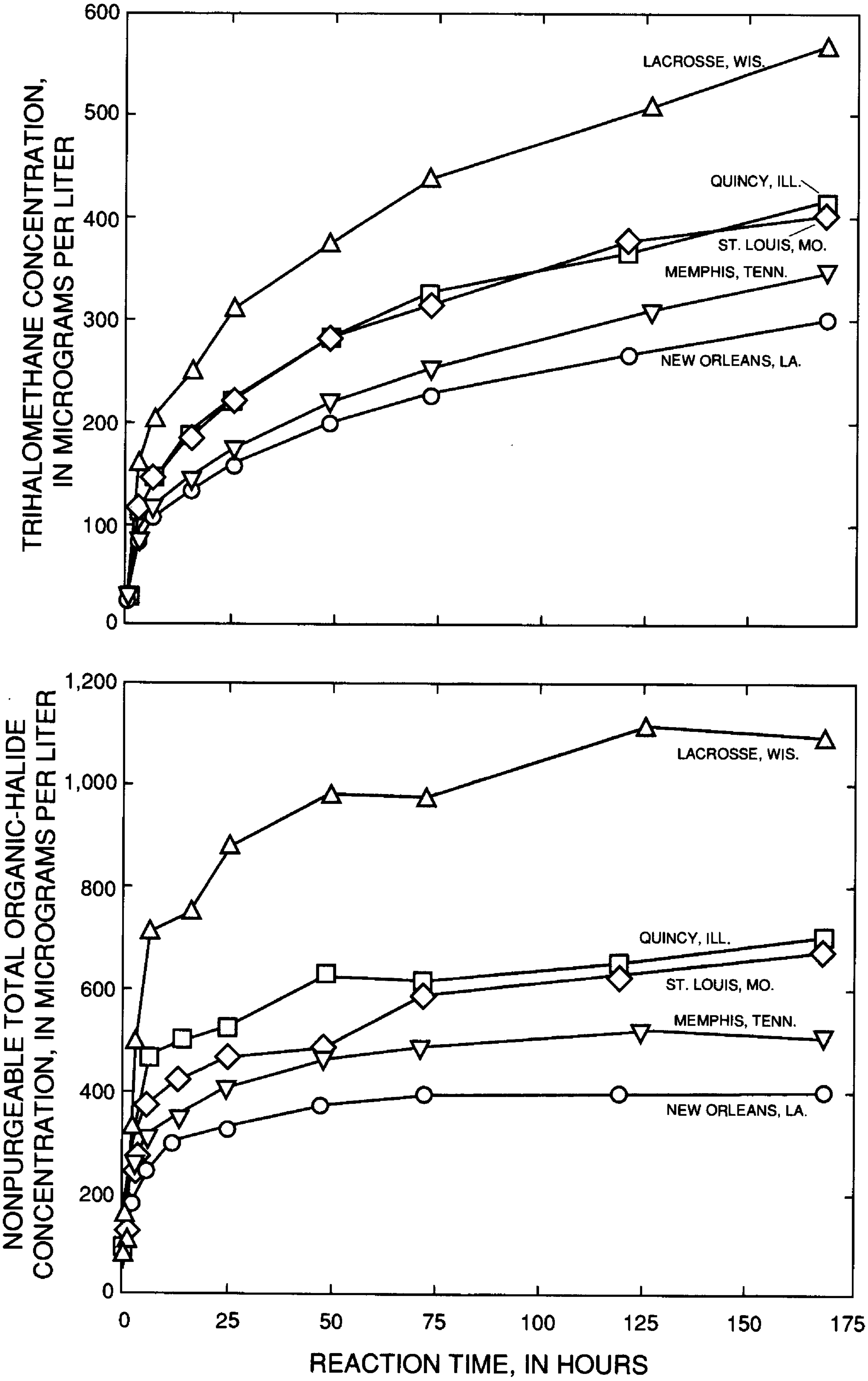

Figure 3.--Trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for several sampling sites along the Mississippi River; initial pH of 7.50 and initial free-chlorine concentration of 30.0 milligrams per liter.

All concentrations were corrected for blank contributions. The blank corrections for chloroform ranged from 0.00 to 1.33 µg/L and averaged 0.35 µg/L for 45 determinations. Average blank corrections for the other three THM compounds were less than 0.02 µg/L. Blank corrections for the NPTOX concentrations ranged from 5.08 to 30.6 µg/L and averaged 14.5 µg/L for 39 determinations for samples from the Mississippi River. Corrections for the Missouri River water sample ranged from 11.1 to 13.7 µg/L and averaged 12.7 µg/L. Corrections for the Ohio River water sample ranged from 11.0 to 12.2 µg/L and averaged 11.4 µg/L.

The three chlorinated THM compounds (chloroform, bromodichloromethane, and chlorodibromomethane) were detected in all samples. Bromoform was not detected in 49 percent of the samples. The detection limit for bromoform for the analytical procedure used in this study was estimated to be about 0.01 µg/L.

For the first type of results, duplicate experiments were done for all nine combinations of initial pH and initial free-chlorine concentration for each water sample. The two vials for the Minneapolis sample for an initial pH of 7.50 and an initial free-chlorine concentration of 15 mg/L had no detectable free-chlorine concentration at the end of the reaction time. The limit of detection of the procedure used for these free-chlorine measurements was 0.1 mg/L. Concentrations for these samples are flagged with an asterisk in tables 2 to indicate that these concentrations could have been affected by the lack of a free-chlorine residual at the end of the experiments.

For the second type of results, duplicate experiments were done for a reaction time of 168.0 hours and single experiments were done for all other reaction times. The 0.00-hour reaction-time samples were samples taken and quenched immediately after addition of the sodium hypochlorite solution to the water sample. The time required to add the sodium hypochlorite solution to the water sample in a separatory funnel, mix the contents, fill the 0.00-hour time vials already containing the quenching agent, and to shake these vials ranged from 30 to 45 seconds.

The first type of results consisting of concentrations of the four THM compounds and the total THM and NPTOX concentrations for a reaction time of 168.0 hours and nine combinations of initial pH and free-chlorine concentration are listed in tables 2–15. The second type of results consisting of concentrations of the four THM compounds and the total THM and NPTOX concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 mg/L are listed in tables 16–27. The concentrations for the 168.0-hour reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 mg/L are included in both the first and the second types of results presented in tables 2-15 and in tables 16-27.

One bottle of the Minneapolis water sample and three bottles of the Davenport water sample froze during storage. Most of the Minneapolis water sample was lost, but almost all of the Davenport water sample was recovered by melting the ice. Previous unpublished results indicated that the THM formation potential of thawed water was considerably less than that of water that had not been frozen. Therefore, formation potential experiments for the Davenport water sample were done for both the thawed water sample and the water sample that had not been frozen. Because of the limited amount of water, however, formation-potential experiments could be done for only six of the nine combinations of initial pH and initial free-chlorine concentration for the thawed-water sample and seven of the nine combinations for the regular water sample (table 5). Also, the concentration-time formation-potential experiments could not be done for the Minneapolis and Davenport water samples because of insufficient water.

Table 2.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Minneapolis, Minn., April 6, 1992

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	384	15.6	0.25	ND	400	1,270
5.50	15.0	388	16.1	.30	ND	404	1,310
5.50	30.0	531	17.2	.24	ND	548	1,630
5.50	30.0	514	16.3	.27	ND	531	1,650
5.50	50.0	639	18.0	.26	ND	657	1,770
5.50	50.0	637	17.6	.23	ND	655	1,860
7.50	15.0	480*	19.4*	.69*	ND*	500*	852*
7.50	15.0	475*	19.0*	.38*	ND*	494*	836*
7.50	30.0	779	24.7	.69	ND	804	1,350
7.50	30.0	755	22.4	.55	ND	778	1,290
7.50	50.0	899	22.4	.42	ND	922	1,370
7.50	50.0	903	23.9	.47	ND	927	1,340
10.00	15.0	813	18.4	.36	ND	832	654
10.00	15.0	823	18.2	.40	ND	842	653
10.00	30.0	1,050	22.8	.49	ND	1,070	798
10.00	30.0	1,050	21.5	.43	ND	1,070	754
10.00	50.0	1,190	24.1	.52	ND	1,210	884
10.00	50.0	1,160	23.6	.48	ND	1,180	955

*Free-chlorine concentration less than the detection limit at reaction time of 168.0 hours.

Table 3.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at LaCrosse, Wis., April 3, 1992

[μg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	Initial CL (mg/L)	Concentration (μg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	338	17.5	0.48	ND	356	993
5.50	15.0	334	18.0	.49	ND	352	1,100
5.50	30.0	428	18.4	.45	ND	447	1,250
5.50	30.0	424	18.3	.46	ND	443	1,210
5.50	50.0	507	19.2	.46	ND	527	1,420
5.50	50.0	504	18.5	.46	ND	523	1,500
7.50	15.0	493	23.9	.81	ND	518	947
7.50	15.0	479	22.4	.75	ND	502	909
7.50	30.0	536	22.8	.71	ND	560	1,100
7.50	30.0	547	24.0	.79	ND	572	1,070
7.50	50.0	714	24.7	.74	ND	739	1,180
7.50	50.0	731	24.8	.73	ND	757	1,120
10.00	15.0	681	23.5	1.01	ND	706	621
10.00	15.0	688	24.0	.90	ND	713	610
10.00	30.0	801	25.7	.94	ND	828	621
10.00	30.0	815	26.0	.88	ND	842	594
10.00	50.0	875	26.4	.97	ND	902	678
10.00	50.0	885	26.5	.98	ND	912	649

Table 4.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Dubuque, Iowa, April 2, 1992

[μg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	Initial CL (mg/L)	Concentration (μg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	336	15.3	0.41	ND	352	970
5.50	15.0	339	15.5	.42	ND	355	955
5.50	30.0	423	15.1	.40	ND	438	1,160
5.50	30.0	423	14.9	.38	ND	438	1,130
5.50	50.0	531	15.7	.34	ND	547	1,340
5.50	50.0	530	16.2	.40	ND	547	1,250
7.50	15.0	469	18.7	.53	ND	488	797
7.50	15.0	477	19.1	.54	ND	497	826
7.50	30.0	553	19.9	.57	ND	573	1,020
7.50	30.0	557	20.0	.55	ND	578	1,050
7.50	50.0	712	20.9	.55	ND	733	1,020
7.50	50.0	706	20.2	.51	ND	727	1,090
10.00	15.0	726	19.6	.66	ND	746	586
10.00	15.0	723	19.2	.65	ND	743	515
10.00	30.0	901	22.0	.71	ND	924	626
10.00	30.0	888	21.3	.60	ND	910	659
10.00	50.0	973	22.2	.62	ND	996	785
10.00	50.0	987	22.6	.64	ND	1,010	737

Table 5.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Davenport, Iowa, April 2, 1992

[μg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	Initial CL (mg/L)	Concentration (μg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
		REGULAR SAMPLE					
5.50	30.0	420	16.7	0.44	ND	437	1,130
5.50	30.0	413	16.8	.43	ND	430	1,130
5.50	50.0	482	17.0	.42	ND	499	1,170
5.50	50.0	486	16.9	.46	ND	503	1,250
7.50	30.0	633	22.5	.67	ND	656	908
7.50	30.0	625	21.9	.63	ND	648	961
7.50	50.0	720	21.9	.63	ND	743	947
7.50	50.0	730	22.2	.64	ND	753	926
10.00	15.0	692	21.0	.78	ND	714	477
10.00	15.0	689	20.4	.76	ND	710	496
10.00	30.0	805	23.1	.74	ND	829	580
10.00	30.0	805	23.0	.76	ND	829	562
10.00	50.0	861	23.0	.73	ND	885	653
10.00	50.0	895	23.9	.76	ND	920	593
		THAWED SAMPLE					
5.50	30.00	387	16.7	0.49	0.11	404	1,080
5.50	30.00	390	16.4	.40	ND	407	1,150
5.50	50.00	462	16.2	.40	ND	479	1,160
5.50	50.00	450	16.2	.41	ND	467	1,160
7.50	30.00	596	22.0	.59	ND	619	832
7.50	30.00	591	20.3	.56	ND	612	825
7.50	50.00	696	22.7	.55	ND	719	914
7.50	50.00	694	22.1	.59	ND	717	883
10.00	30.00	820	21.8	.71	ND	843	571
10.00	30.00	818	22.6	.82	ND	841	562
10.00	50.00	860	22.0	.65	ND	883	603
10.00	50.00	888	22.6	.66	ND	911	656

Table 6.–Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Quincy, Ill., April 1, 1992

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	248	17.4	0.82	ND	266	744
5.50	15.0	252	17.3	.72	ND	270	731
5.50	30.0	300	16.8	.64	ND	317	860
5.50	30.0	300	17.2	.69	ND	318	807
5.50	50.0	363	17.3	.78	ND	381	977
5.50	50.0	368	17.5	.71	ND	386	911
7.50	15.0	375	22.4	1.17	ND	399	654
7.50	15.0	393	23.5	1.25	ND	418	688
7.50	30.0	392	22.4	1.17	ND	416	694
7.50	30.0	395	21.8	1.08	ND	418	714
7.50	50.0	517	23.4	1.12	ND	542	838
7.50	50.0	514	22.8	1.10	ND	538	819
10.00	15.0	499	23.1	1.56	.03	524	455
10.00	15.0	502	23.6	1.61	ND	527	406
10.00	30.0	568	25.0	1.60	ND	595	401
10.00	30.0	561	24.9	1.54	ND	587	401
10.00	50.0	588	24.7	1.51	ND	614	483
10.00	50.0	589	23.9	1.56	ND	614	525

Table 7.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Missouri River 1.6 kilometers upstream from confluence with Mississippi River, March 31, 1992

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	198	41.7	7.19	0.24	247	647
5.50	15.0	190	40.4	6.93	.24	238	622
5.50	30.0	230	41.0	6.10	.17	277	734
5.50	30.0	233	40.8	5.83	.17	280	727
5.50	50.0	287	44.0	5.82	.12	337	759
5.50	50.0	288	45.0	6.00	.13	339	748
7.50	15.0	299	58.5	10.7	.36	369	555
7.50	15.0	309	60.5	11.0	.37	381	530
7.50	30.0	328	59.1	10.3	.29	398	632
7.50	30.0	330	58.4	10.1	.29	399	634
7.50	50.0	414	61.8	10.4	.30	486	610
7.50	50.0	417	62.0	10.4	.30	490	649
10.00	15.0	416	61.0	12.4	.71	490	323
10.00	15.0	403	59.5	12.3	.71	476	324
10.00	30.0	453	62.2	12.2	.64	528	326
10.00	30.0	446	60.8	11.9	.61	519	355
10.00	50.0	472	63.3	12.0	.58	548	378
10.00	50.0	474	64.1	12.2	.59	551	385

Table 8.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at St. Louis, Mo., March 31, 1992

[μg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (μg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	221	27.7	2.81	0.10	252	725
5.50	15.0	217	28.1	2.94	ND	248	737
5.50	30.0	272	29.0	2.56	ND	304	858
5.50	30.0	276	30.0	2.82	ND	309	845
5.50	50.0	361	32.8	2.76	.01	397	904
5.50	50.0	327	31.0	2.67	.01	361	863
7.50	15.0	371	41.9	4.49	.07	417	634
7.50	15.0	369	41.5	4.47	.07	415	667
7.50	30.0	361	41.1	4.31	.06	406	663
7.50	30.0	357	39.4	4.17	.06	401	687
7.50	50.0	451	42.3	4.15	.06	498	699
7.50	50.0	460	43.7	4.41	.09	508	700
10.00	15.0	472	42.8	5.52	.17	520	371
10.00	15.0	468	42.5	5.51	.17	516	386
10.00	30.0	516	43.3	5.12	.14	565	428
10.00	30.0	517	44.2	5.13	.14	566	419
10.00	50.0	545	44.8	5.18	.13	595	443
10.00	50.0	544	44.8	5.09	.14	594	450

Table 9.–Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Cairo, Ill., March 30, 1992

[μg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Initial pH	Initial CL (mg/L)	Concentration (μg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	266	23.9	1.68	ND	292	750
5.50	15.0	263	23.7	1.65	ND	288	760
5.50	30.0	298	23.3	1.41	ND	323	913
5.50	30.0	303	23.8	1.49	ND	328	873
5.50	50.0	358	24.2	1.41	ND	384	914
5.50	50.0	360	24.3	1.43	ND	386	916
7.50	15.0	372	32.2	2.33	ND	407	605
7.50	15.0	364	31.6	2.28	ND	399	597
7.50	30.0	410	32.4	2.22	ND	445	719
7.50	30.0	408	32.4	2.24	ND	443	715
7.50	50.0	505	33.5	2.27	ND	541	700
7.50	50.0	505	32.9	2.22	ND	540	691
10.00	15.0	589	36.9	2.86	ND	629	460
10.00	15.0	595	37.5	2.94	.06	636	447
10.00	30.0	615	37.1	2.81	ND	655	441
10.00	30.0	616	37.1	2.78	ND	656	458
10.00	50.0	663	37.3	2.75	ND	703	464
10.00	50.0	655	38.4	2.86	ND	696	496

Table 10.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Ohio River 1.6 kilometers upstream from confluence with Mississippi River, March 30, 1992

[μg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (μg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	138	16.2	1.44	0.03	156	392
5.50	15.0	143	16.9	1.50	.03	161	391
5.50	30.0	171	16.4	1.36	.01	189	451
5.50	30.0	172	16.0	1.32	.02	189	448
5.50	50.0	229	18.2	1.49	.01	249	477
5.50	50.0	226	18.1	1.44	.02	246	475
7.50	15.0	205	22.0	2.29	.04	229	323
7.50	15.0	208	21.9	2.25	.03	232	341
7.50	30.0	234	23.3	2.29	.03	260	343
7.50	30.0	241	24.2	2.35	.03	268	357
7.50	50.0	273	22.3	2.21	.04	298	360
7.50	50.0	277	23.2	2.27	.03	302	355
10.00	15.0	304	23.6	2.71	.07	330	216
10.00	15.0	303	23.0	2.63	.07	329	217
10.00	30.0	328	24.1	2.61	.06	355	233
10.00	30.0	323	24.7	2.63	.06	350	242
10.00	50.0	360	24.4	2.48	.05	387	311
10.00	50.0	372	24.9	2.52	.05	399	275

Table 11.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Memphis, Tenn., March 29, 1992

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	191	17.4	1.37	ND	210	575
5.50	15.0	206	18.2	1.41	ND	226	573
5.50	30.0	228	17.5	1.19	ND	247	611
5.50	30.0	220	16.9	1.18	ND	238	621
5.50	50.0	288	19.5	1.30	.01	309	658
5.50	50.0	285	18.8	1.25	ND	305	719
7.50	15.0	[1]289	[1]24.8	[1]2.06	[1].02	[1]316	[1]473
7.50	15.0	[1]284	[1]24.0	[1]2.00	[1].02	[1]310	[1]480
7.50	30.0	314	25.9	2.05	.02	342	498
7.50	30.0	325	26.4	2.07	.02	353	528
7.50	50.0	[2]393	[2]25.9	[2]2.04	[2].02	[2]421	[2]496
7.50	50.0	[2]385	[2]25.3	[2]1.97	[2].02	[2]412	[2]521
10.00	15.0	424	27.5	2.41	.04	454	303
10.00	15.0	426	27.3	2.37	.04	456	288
10.00	30.0	470	28.1	2.35	.04	500	316
10.00	30.0	466	28.0	2.34	.04	496	319
10.00	50.0	480	27.3	2.16	.03	509	339
10.00	50.0	500	28.6	2.27	.04	531	346

[1] Reaction time of 168.3 hours rather than 168.0 hours.

[2] Reaction time of 168.2 hours rather than 168.0 hours.

Table 12.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Greenville, Miss., March 28, 1992

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	170	18.6	1.39	ND	190	438
5.50	15.0	173	19.2	1.47	ND	194	459
5.50	30.0	220	19.8	1.37	.01	241	563
5.50	30.0	217	19.2	1.35	.02	238	577
5.50	50.0	262	20.2	1.37	.01	284	616
5.50	50.0	260	20.4	1.36	.01	282	618
7.50	15.0	268	26.1	2.37	.03	296	461
7.50	15.0	273	26.2	2.38	.03	302	452
7.50	30.0	308	27.9	2.40	.03	338	483
7.50	30.0	304	26.8	2.28	.03	333	474
7.50	50.0	372	27.0	2.23	.03	401	485
7.50	50.0	379	27.5	2.27	.03	409	545
10.00	15.0	398	29.2	2.96	.07	430	288
10.00	15.0	392	27.7	2.75	.06	423	294
10.00	30.0	444	29.4	2.74	.06	476	271
10.00	30.0	454	30.1	2.78	.05	487	298
10.00	50.0	478	30.7	2.79	.05	512	294
10.00	50.0	499	31.0	2.79	.05	533	307

Table 13.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Natchez, Miss., March 26, 1992

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	186	19.6	1.62	ND	207	512
5.50	15.0	183	18.7	1.52	ND	203	529
5.50	30.0	220	19.2	1.60	ND	241	564
5.50	30.0	224	20.2	1.60	.02	246	571
5.50	50.0	271	20.3	1.48	.02	293	605
5.50	50.0	271	20.1	1.51	.01	293	612
7.50	15.0	274	26.6	2.42	.03	303	421
7.50	15.0	271	26.2	2.39	.03	300	434
7.50	30.0	313	26.7	2.34	.02	342	472
7.50	30.0	318	27.1	2.33	ND	347	481
7.50	50.0	369	26.9	2.29	.02	398	471
7.50	50.0	362	26.4	2.24	.02	391	463
10.00	15.0	399	28.8	2.99	.07	431	299
10.00	15.0	397	28.6	2.96	.08	429	286
10.00	30.0	427	28.5	2.75	.06	458	315
10.00	30.0	434	30.6	3.23	.07	468	312
10.00	50.0	468	30.0	2.83	.06	501	333
10.00	50.0	476	29.9	2.80	.06	509	354

Table 14.–Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at Baton Rouge, La., March 26, 1992

[µg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (µg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	189	19.3	1.62	ND	210	516
5.50	15.0	186	19.0	1.62	ND	207	531
5.50	30.0	213	18.6	1.43	ND	233	569
5.50	30.0	216	18.8	1.46	ND	236	580
5.50	50.0	268	19.6	1.55	.01	289	582
5.50	50.0	266	19.1	1.45	.01	287	620
7.50	15.0	274	25.6	2.43	ND	302	428
7.50	15.0	278	26.2	2.48	.04	307	427
7.50	30.0	345	25.8	2.34	.01	373	472
7.50	30.0	323	25.9	2.34	ND	351	449
7.50	50.0	362	25.3	2.28	.03	390	455
7.50	50.0	362	25.6	2.29	.03	390	474
10.00	15.0	396	27.1	2.84	.07	426	278
10.00	15.0	402	27.4	2.92	.07	432	286
10.00	30.0	431	28.0	2.79	.06	462	290
10.00	30.0	437	28.1	2.80	.06	468	313
10.00	50.0	459	27.8	2.68	.06	490	329
10.00	50.0	468	28.4	2.74	ND	499	336

Table 15.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations for a reaction time of 168.0 hours as a function of initial pH and initial free-chlorine concentration, Mississippi River at New Orleans, La., March 25, 1992

[μg/L, microgram per liter; CL, free-chlorine concentration; mg/L, milligram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Initial pH	Initial CL (mg/L)	Concentration (μg/L)					
		$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
5.50	15.0	161	31.0	5.35	0.13	197	466
5.50	15.0	160	30.3	4.93	.12	195	489
5.50	30.0	183	29.9	4.34	.09	217	515
5.50	30.0	180	29.0	4.10	.09	213	514
5.50	50.0	220	29.8	3.89	.07	254	528
5.50	50.0	226	31.3	4.10	.08	261	542
7.50	15.0	225	41.4	7.72	.23	274	402
7.50	15.0	227	42.3	7.85	.25	277	363
7.50	30.0	245	40.3	7.45	.19	293	401
7.50	30.0	254	40.9	7.54	.19	303	401
7.50	50.0	307	44.4	7.51	.21	359	387
7.50	50.0	306	43.8	7.47	.21	357	399
10.00	15.0	322	42.6	8.68	.44	374	252
10.00	15.0	327	44.5	8.93	.45	381	256
10.00	30.0	359	45.2	8.65	.40	413	278
10.00	30.0	360	45.3	8.70	.40	414	272
10.00	50.0	379	44.9	8.17	.35	432	300
10.00	50.0	386	47.0	8.56	.36	442	295

Table 16.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at LaCrosse, Wis., April 3, 1992

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	34.6	1.91	0.07	ND	36.6	158
2.00	147	10.7	.35	ND	158	494
6.00	190	12.8	.42	ND	203	706
14.00	234	14.8	.43	ND	249	745
24.00	292	17.5	.55	ND	310	877
48.00	352	18.9	.63	ND	372	979
72.00	415	21.3	.70	ND	437	974
126.0	486	22.0	.71	ND	509	1,110
168.0	536	22.8	.71	ND	560	1,100
168.0	547	24.0	.79	ND	572	1,070

Table 17.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Dubuque, Iowa, April 2, 1992

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	38.1	1.94	0.03	ND	40.1	151
2.00	160	9.43	.25	ND	170	432
6.00	202	11.5	.31	ND	214	615
12.18	244	13.2	.39	ND	258	670
24.00	304	15.3	.44	ND	320	731
48.00	392	18.0	.54	ND	411	820
72.00	435	18.4	.54	ND	454	858
121.0	490	18.8	.55	ND	509	970
168.0	553	19.9	.57	ND	573	1,020
168.0	557	20.0	.55	ND	578	1,050

Table 18.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Quincy, Ill., April 1, 1992

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	27.6	2.06	0.13	ND	29.8	98.9
2.00	101	11.1	.57	ND	113	297
6.00	133	13.2	.72	ND	147	462
13.00	170	15.2	.81	ND	186	491
24.00	203	16.7	.88	ND	221	523
48.00	259	18.6	1.00	ND	279	626
72.00	304	20.2	1.08	ND	325	616
120.0	345	21.2	1.15	ND	367	650
168.0	392	22.4	1.17	ND	416	694
168.0	395	21.8	1.08	ND	418	714

Table 19.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Missouri River 1.6 kilometers upstream from confluence with Mississippi River, March 31, 1992

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	18.4	5.06	1.35	0.05	24.9	138
2.00	73.5	26.1	5.96	.18	106	286
6.00	97.5	35.6	8.01	.24	141	346
12.00	125	39.0	8.30	.25	173	421
24.00	166	44.8	9.03	.27	220	446
49.00	213	48.9	9.66	.27	272	524
71.00	248	53.3	10.0	.27	312	566
121.0	278	51.7	9.25	.25	339	552
168.0	328	59.1	10.3	.29	398	632
168.0	330	58.4	10.1	.29	399	634

Table 20.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at St. Louis, Mo., March 31, 1992

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide; ND, not detected]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	21.5	3.32	0.50	ND	25.3	85.8
2.00	90.1	19.9	2.47	.04	113	216
6.00	120	24.2	3.07	.05	147	366
12.00	151	27.8	3.62	.06	182	412
24.00	189	30.7	3.67	ND	223	462
48.00	240	35.4	4.09	.06	280	485
72.00	272	36.9	4.12	.06	313	594
121.0	329	41.1	4.63	.06	375	631
168.0	361	41.1	4.31	.06	406	663
168.0	357	39.4	4.17	.06	401	687

Table 21.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Cairo, Ill., March 30, 1992

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	28.2	2.91	0.29	ND	31.4	118
2.00	100	14.3	1.23	.02	116	320
6.00	139	19.3	1.60	.03	160	411
12.00	162	20.6	1.70	.02	184	509
24.00	208	24.2	1.91	.02	234	566
49.00	266	25.8	1.89	.01	294	589
72.00	291	28.0	2.01	.02	321	654
126.0	348	30.6	2.25	.02	381	713
168.0	410	32.4	2.22	ND	445	719
168.0	408	32.4	2.24	ND	443	715

Table 22.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Ohio River 1.6 kilometers upstream from confluence with Mississippi River, March 30, 1992

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	14.0	1.78	0.17	ND	16.0	66.9
3.00	59.3	11.2	1.30	.02	71.8	177
6.00	69.8	13.1	1.53	.02	84.4	235
12.00	86.4	15.1	1.76	.03	103	227
22.50	109	17.2	1.96	.02	128	266
48.00	143	19.1	2.05	.03	164	298
72.00	172	20.3	2.13	.03	194	313
123.00	208	21.8	2.18	.03	232	345
168.00	234	23.3	2.29	.03	260	343
168.00	241	24.2	2.35	.03	268	357

Table 23.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Memphis, Tenn., March 29, 1992

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	23.2	2.86	0.26	ND	26.3	102
2.00	71.8	10.6	.98	ND	83.4	238
6.00	97.5	14.4	1.37	ND	113	305
13.00	125	16.4	1.56	.01	143	348
24.00	154	18.2	1.66	.01	174	402
48.00	198	20.5	1.74	.02	220	460
72.00	229	21.8	1.79	.02	253	486
126.0	282	24.2	2.07	.02	308	521
168.00	314	25.9	2.05	.02	342	498
168.0	325	26.4	2.07	.02	353	528

Table 24.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Greenville, Miss., March 28, 1992

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	20.3	2.57	0.23	ND	23.1	89.9
2.00	76.5	13.2	1.31	.01	91.0	233
6.00	97.4	16.3	1.67	.02	115	307
12.00	120	18.2	1.87	.02	140	335
24.00	148	20.1	1.94	.02	170	356
48.00	192	23.0	2.14	.02	217	380
72.00	223	24.6	2.23	.03	250	441
121.0	264	26.0	2.27	ND	292	460
168.0	308	27.9	2.40	.03	338	483
168.0	304	26.8	2.28	.03	333	474

Table 25.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Natchez, Miss., March 26, 1992

[μg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (μg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	19.9	2.49	0.14	ND	22.5	88.0
2.00	74.8	12.6	1.29	.02	88.7	225
6.00	101	16.6	1.71	.02	119	296
12.00	125	17.6	1.88	.02	144	333
24.00	158	20.5	2.03	.02	181	382
48.00	199	22.5	2.21	.02	224	424
72.00	229	22.7	2.12	.02	254	426
125.0	272	25.3	2.26	ND	300	455
168.0	313	26.7	2.34	.02	342	472
168.0	318	27.1	2.33	ND	347	481

Table 26.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide-concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at Baton Rouge, La., March 26, 1992

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	18.3	2.49	0.22	ND	21.0	82.3
2.00	74.5	13.4	1.06	ND	89.0	210
6.00	95.3	16.0	1.60	.02	113	298
12.00	121	18.0	1.88	.02	141	330
24.00	154	20.0	2.00	ND	176	378
48.00	200	23.2	2.24	.03	225	394
72.00	237	23.7	2.20	ND	263	444
126.0	285	25.8	2.32	ND	313	457
168.0	345	25.8	2.34	.01	373	472
168.0	323	25.9	2.34	ND	351	449

Table 27.--Concentrations of the four trihalomethane compounds and the total trihalomethane and nonpurgeable total organic-halide concentrations as a function of reaction time for an initial pH of 7.50 and an initial free-chlorine concentration of 30.0 milligrams per liter, Mississippi River at New Orleans, La., March 25, 1992

[µg/L, microgram per liter; $CHCl_3$, chloroform; $BrCHCl_2$, bromodichloromethane; $ClCHBr_2$, chlorodibromomethane; $CHBr_3$, bromoform; THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Reaction time (hours)	Concentration (µg/L)					
	$CHCl_3$	$BrCHCl_2$	$ClCHBr_2$	$CHBr_3$	Total THM	NPTOX
0.00	15.8	3.74	0.77	0.02	20.3	71.6
2.03	59.0	19.0	4.36	.12	82.5	180
6.00	79.1	24.1	5.43	.15	109	245
12.00	102	28.4	6.44	.16	137	296
24.00	122	29.8	6.66	.17	159	323
48.00	159	33.8	7.15	.19	200	372
72.00	185	35.9	7.39	.18	228	395
120.5	220	39.4	7.61	.20	267	396
168.0	245	40.3	7.45	.19	293	401
168.0	254	40.9	7.54	.19	303	401

Ancillary Data

Values of pH as a Function of Reaction Time

Values of pH as a function of reaction time for the different combinations of initial pH and initial free-chlorine concentration are listed in tables 28-41.

Table 28.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Minneapolis, Minn., April 6, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
Initial pH = 5.50					
0.00	5.50	0.00	5.50	0.00	5.50
1.68	6.48	1.42	6.62	1.23	6.88
26.02	6.44	25.77	6.62	25.60	6.77
54.32	6.48	53.97	6.69	53.80	6.79
78.62	6.51	78.37	6.77	78.20	6.78
102.7	6.57	102.4	6.84	102.3	6.82
126.8	6.61	126.6	6.89	126.4	6.82
170.4	6.69	170.2	7.07	170.0	6.87
Initial pH = 7.50					
.00	7.50	.00	7.50	.00	7.50
2.42	8.19	2.25	8.38	2.08	8.57
26.80	8.09	26.63	8.23	26.47	8.43
54.98	8.12	54.82	8.19	54.63	8.39
79.40	8.13	79.23	8.13	79.07	8.36
103.5	8.19	103.3	8.14	103.1	8.34
127.6	8.22	127.5	8.13	127.3	8.32
171.2	8.29	171.0	8.13	170.8	8.31
Initial pH = 10.00					
.00	10.00	.00	10.00	.00	10.00
.53	9.91	.37	9.95	.22	9.98
24.92	9.78	24.75	9.83	24.60	9.86
53.08	9.77	52.90	9.81	52.73	9.84
77.52	9.74	77.35	9.78	77.20	9.81
101.6	9.74	101.4	9.79	101.2	9.82
125.8	9.70	125.6	9.77	125.4	9.79
169.3	9.67	169.1	9.75	169.0	9.77

Table 29.–Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at LaCrosse, Wis., April 3, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	**pH**	**Reaction time (hours)**	**pH**	**Reaction time (hours)**	**pH**
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.77	6.63	1.62	6.67	1.47	6.90
29.18	6.61	29.03	6.62	28.88	6.80
54.10	6.64	53.95	6.60	53.80	6.78
78.02	6.70	77.87	6.66	77.72	6.83
125.3	6.74	125.1	6.70	125.0	6.85
170.0	6.82	169.9	6.76	169.7	6.87
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.62	8.25	2.30	8.24	2.40	8.55
30.00	8.15	29.68	8.10	29.80	8.47
54.95	8.09	54.62	8.05	54.73	8.41
78.83	8.11	78.52	8.09	78.63	8.41
126.1	8.11	125.8	8.12	125.9	8.42
170.9	8.14	170.6	8.11	170.7	8.40
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.80	9.66	.65	9.80	.50	9.83
28.18	9.54	28.03	9.69	27.88	9.73
53.12	9.49	52.97	9.64	52.82	9.69
77.03	9.49	76.88	9.64	76.70	9.68
124.3	9.45	124.2	9.60	124.0	9.66
169.1	9.42	168.9	9.57	168.8	9.64

Table 30.–Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Dubuque, Iowa, April 2, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.80	6.77	1.65	6.82	1.48	7.18
24.00	6.65	23.85	6.71	23.68	7.04
47.98	6.64	47.83	6.71	47.67	7.03
71.88	6.65	71.73	6.75	71.57	7.12
120.2	6.60	120.1	6.74	119.9	7.16
170.3	6.68	170.1	6.82	169.9	7.33
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.68	8.32	2.35	8.37	2.50	8.65
24.90	8.16	24.57	8.20	24.72	8.52
48.88	8.14	48.53	8.16	48.68	8.49
72.78	8.13	72.45	8.13	72.60	8.47
121.1	8.06	120.8	8.06	121.0	8.40
171.2	8.09	170.8	8.08	171.0	8.39
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.70	9.89	.57	9.97	.40	10.00
22.95	9.65	22.82	9.75	22.67	9.78
46.93	9.62	46.80	9.72	46.65	9.75
70.85	9.60	70.72	9.70	70.57	9.74
119.2	9.53	119.1	9.63	118.9	9.67
169.2	9.53	169.1	9.63	168.9	9.64

Table 31.—Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Davenport, Iowa, April 2, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter; NS, no sample because of insufficient water]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
Initial pH = 5.50 (regular sample)					
NS	NS	0.00	5.50	0.00	5.50
NS	NS	1.95	6.70	1.77	6.97
NS	NS	30.75	6.65	30.55	6.81
NS	NS	52.62	6.70	52.38	6.82
NS	NS	76.55	6.80	76.35	6.83
NS	NS	123.4	6.91	123.2	6.88
NS	NS	172.4	7.15	172.2	6.89
Initial pH = 7.50 (regular sample)					
NS	NS	.00	7.50	.00	7.50
NS	NS	2.97	8.38	2.78	8.59
NS	NS	31.82	8.21	31.57	8.46
NS	NS	53.67	8.17	53.42	8.42
NS	NS	77.60	8.13	77.42	8.40
NS	NS	124.4	8.12	124.2	8.39
NS	NS	173.4	8.10	173.2	8.38
Initial pH = 10.00 (regular sample)					
0.00	10.00	.00	10.00	.00	10.00
.58	9.90	.42	9.93	.22	9.97
29.38	9.64	29.22	9.66	29.02	9.71
51.22	9.61	51.05	9.64	50.83	9.69
75.22	9.58	75.05	9.61	74.85	9.67
122.1	9.55	121.9	9.59	121.7	9.65
171.0	9.51	170.8	9.54	170.6	9.63

Table 31.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Davenport, Iowa, April 2, 1992--Continued

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50 (thawed sample)			
NS	NS	0.00	5.50	0.00	5.50
NS	NS	2.50	6.70	2.32	6.93
NS	NS	31.37	6.63	31.18	7.01
NS	NS	53.17	6.68	53.02	7.17
NS	NS	77.17	6.81	76.98	7.31
NS	NS	124.0	6.98	123.8	7.56
NS	NS	173.0	7.08	172.8	7.70
		Initial pH = 7.50 (thawed sample)			
NS	NS	.00	7.50	.00	7.50
NS	NS	3.53	8.39	3.30	8.61
NS	NS	32.32	8.22	32.15	8.48
NS	NS	54.13	8.19	53.93	8.45
NS	NS	78.17	8.16	77.93	8.44
NS	NS	125.0	8.16	124.8	8.44
NS	NS	174.0	8.16	173.8	8.44
		Initial pH = 10.00 (thawed sample)			
NS	NS	.00	10.00	.00	10.00
NS	NS	1.07	9.92	.87	9.94
NS	NS	29.87	9.73	29.67	9.77
NS	NS	51.70	9.71	51.48	9.76
NS	NS	75.70	9.68	75.50	9.73
NS	NS	122.6	9.66	122.4	9.72
NS	NS	171.6	9.63	171.4	9.69

Table 32.—Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Quincy, Ill., April 1, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	**pH**	**Reaction time (hours)**	**pH**	**Reaction time (hours)**	**pH**
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.73	6.71	1.57	6.74	1.40	6.99
31.22	6.63	31.05	6.71	30.88	6.87
54.17	6.67	54.00	6.83	53.83	6.92
79.00	6.74	78.83	7.08	78.67	7.01
119.4	7.04	119.3	7.40	119.1	7.05
170.2	7.16	170.0	7.56	169.9	7.11
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.70	8.28	2.30	8.16	2.50	8.53
32.18	8.15	31.78	8.03	31.97	8.42
55.12	8.15	54.72	8.04	54.92	8.40
79.97	8.18	79.57	8.03	79.77	8.38
120.4	8.21	120.0	8.06	120.2	8.38
171.2	8.20	170.8	8.09	171.0	8.36
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.75	9.74	.58	9.79	.43	9.81
30.22	9.64	30.05	9.70	29.90	9.73
53.17	9.60	53.00	9.66	52.85	9.71
78.02	9.58	77.85	9.64	77.70	9.70
118.4	9.57	118.3	9.61	118.1	9.69
169.2	9.53	169.1	9.57	168.9	9.66

Table 33.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Missouri River 1.6 kilometers upstream from confluence with Mississippi River, March 31, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.72	6.70	1.53	6.76	1.35	7.05
22.33	6.66	22.17	6.71	21.98	6.97
48.78	6.83	48.62	6.79	48.42	7.07
70.78	6.87	70.62	6.84	70.43	7.19
119.9	6.93	119.8	6.91	119.6	7.36
170.3	6.96	170.2	7.03	170.0	7.56
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.65	8.31	2.32	8.31	2.45	8.59
23.25	8.22	22.92	8.22	23.03	8.53
49.72	8.21	49.38	8.20	49.50	8.50
71.75	8.22	71.40	8.19	71.52	8.49
120.9	8.26	120.5	8.21	120.7	8.47
171.2	8.31	170.9	8.20	171.0	8.47
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.67	9.81	.50	9.85	.33	9.87
21.27	9.64	21.10	9.72	20.93	9.75
47.73	9.58	47.57	9.68	47.40	9.72
69.75	9.53	69.58	9.65	69.42	9.69
118.9	9.41	118.7	9.63	118.6	9.67
169.3	9.35	169.1	9.61	168.9	9.66

Table 34.–Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at St. Louis, Mo., March 31, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.68	6.72	1.52	6.78	1.35	7.03
23.80	6.66	23.63	6.77	23.47	6.96
47.85	6.72	47.68	6.92	47.52	7.04
71.78	6.79	71.62	6.99	71.45	7.08
120.3	6.89	120.1	7.22	119.9	7.27
170.3	6.96	170.1	7.34	170.0	7.43
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.60	8.39	2.28	8.29	2.40	8.61
24.72	8.27	24.40	8.20	24.52	8.51
48.77	8.24	48.43	8.19	48.55	8.48
72.70	8.26	72.38	8.21	72.50	8.46
121.2	8.29	120.8	8.29	121.0	8.45
171.2	8.31	170.9	8.36	171.0	8.45
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.67	9.90	.50	9.93	.35	9.94
22.80	9.71	22.63	9.76	22.48	9.80
46.83	9.67	46.67	9.72	46.52	9.77
70.77	9.66	70.60	9.71	70.45	9.76
119.2	9.62	119.1	9.69	118.9	9.75
169.3	9.60	169.1	9.68	169.0	9.73

Table 35.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Cairo, Ill., March 30, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.73	6.71	1.57	6.74	1.42	7.00
25.30	6.65	25.12	6.67	24.95	6.92
53.95	6.76	53.75	6.77	53.60	6.95
78.68	6.79	78.52	6.82	78.37	6.97
125.2	7.09	125.0	7.00	124.8	7.07
170.3	7.21	170.1	7.20	170.0	7.10
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.68	8.28	2.35	8.29	2.48	8.57
26.22	8.20	25.88	8.20	25.98	8.50
54.87	8.14	54.53	8.15	54.67	8.46
79.62	8.16	79.28	8.16	79.38	8.47
126.1	8.25	125.8	8.18	125.9	8.45
171.2	8.31	170.9	8.22	171.0	8.45
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.73	9.78	.57	9.83	.42	9.85
24.23	9.63	24.07	9.69	23.90	9.73
52.92	9.56	52.73	9.64	52.58	9.68
77.63	9.56	77.47	9.64	77.32	9.67
124.2	9.51	124.0	9.60	123.8	9.64
169.3	9.49	169.1	9.58	169.0	9.62

Table 36.–Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Ohio River 1.6 kilometers upstream from confluence with Mississippi River, March 30, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.77	6.91	1.60	7.20	1.43	7.62
25.70	6.85	25.53	7.12	25.37	7.53
48.50	6.86	48.33	7.14	48.17	7.53
71.92	6.89	71.75	7.17	71.57	7.54
122.4	6.95	122.3	7.25	122.1	7.53
170.4	6.96	170.2	7.29	170.0	7.55
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.65	8.49	2.32	8.67	2.45	8.91
26.58	8.37	26.25	8.57	26.38	8.82
49.37	8.32	49.03	8.55	49.15	8.80
72.78	8.29	72.45	8.53	72.58	8.79
123.3	8.24	122.9	8.47	123.1	8.73
171.2	8.21	171.0	8.48	171.0	8.70
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.68	9.97	.52	10.02	.32	10.04
24.63	9.77	24.47	9.81	24.27	9.84
47.40	9.69	47.23	9.74	47.03	9.77
70.83	9.64	70.67	9.69	70.47	9.73
121.4	9.59	121.2	9.65	121.0	9.70
169.3	9.56	169.1	9.60	168.9	9.69

Table 37.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Memphis, Tenn., March 29, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
Initial pH = 5.50					
0.00	5.50	0.00	5.50	0.00	5.50
1.72	6.75	1.53	6.90	1.37	7.27
29.82	6.68	29.62	6.82	29.42	7.15
55.42	6.71	55.23	6.93	55.07	7.18
77.20	6.77	77.00	7.02	76.83	7.23
125.1	6.86	124.9	7.05	124.8	7.31
170.6	6.97	170.4	7.28	170.2	7.42
Initial pH = 7.50					
.00	7.50	.00	7.50	.00	7.50
2.65	8.36	2.28	8.44	2.43	8.75
30.68	8.24	30.28	8.66	30.43	8.64
56.35	8.21	55.98	8.30	56.13	8.64
78.12	8.20	77.75	8.29	77.90	8.62
126.0	8.21	125.7	8.27	125.8	8.58
171.5	8.24	171.2	8.27	171.3	8.56
Initial pH = 10.00					
.00	10.00	.00	10.00	.00	10.00
.68	9.95	.52	10.00	.35	10.03
28.68	9.64	28.50	9.72	28.33	9.78
54.38	9.53	54.22	9.66	54.05	9.72
76.15	9.48	75.98	9.63	75.82	9.69
124.1	9.34	123.9	9.58	123.7	9.66
169.5	9.24	169.4	9.56	169.2	9.65

Table 38.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Greenville, Miss., March 28, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
Initial pH = 5.50					
0.00	5.50	0.00	5.50	0.00	5.50
1.43	6.55	1.35	6.80	1.25	7.20
26.90	6.52	26.82	6.72	26.72	7.08
54.12	6.60	53.97	6.75	53.80	7.12
78.02	6.65	77.87	6.78	77.67	7.15
121.2	6.71	121.0	7.02	120.8	7.19
170.5	6.76	170.3	7.04	170.2	7.24
Initial pH = 7.50					
.00	7.50	.00	7.50	.00	7.50
2.53	8.44	2.27	8.56	2.48	8.80
28.00	8.28	27.73	8.41	27.93	8.64
55.02	8.26	54.68	8.39	54.80	8.63
78.88	8.25	78.48	8.39	78.60	8.60
122.1	8.26	121.7	8.40	121.9	8.58
171.4	8.28	171.0	8.42	171.2	8.56
Initial pH = 10.00					
.00	10.00	.00	10.00	.00	10.00
.87	10.08	.77	10.10	.67	10.12
26.32	9.74	26.22	9.75	26.10	9.81
53.12	9.67	52.95	9.71	52.77	9.76
76.92	9.64	76.72	9.69	76.53	9.74
120.2	9.61	120.0	9.66	119.8	9.70
169.5	9.57	169.3	9.63	169.1	9.68

Table 39.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Natchez, Miss., March 26, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.42	6.80	1.30	6.93	1.18	7.42
24.28	6.82	24.17	6.92	24.05	7.32
47.50	6.91	47.38	6.93	47.27	7.36
76.25	7.05	76.05	6.96	75.85	7.41
124.7	7.31	124.5	7.07	124.3	7.44
170.4	7.51	170.2	7.14	170.0	7.60
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.80	8.41	2.53	8.56	2.73	8.81
25.67	8.29	25.40	8.44	25.60	8.69
48.88	8.25	48.62	8.40	48.82	8.66
77.35	8.26	77.02	8.39	77.13	8.63
125.8	8.25	125.5	8.36	125.6	8.59
171.5	8.27	171.2	8.37	171.3	8.56
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.75	9.98	.58	10.06	.48	10.10
23.63	9.74	23.47	9.82	23.37	9.86
46.83	9.64	46.67	9.74	46.57	9.79
75.00	9.60	74.83	9.71	74.73	9.77
123.6	9.56	123.3	9.67	123.1	9.75
169.3	9.56	169.0	9.68	168.9	9.73

Table 40.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, Mississippi River at Baton Rouge, La., March 26, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.42	6.75	1.32	6.95	1.23	7.38
54.58	6.77	54.40	7.08	54.23	7.33
77.38	6.79	77.22	7.11	77.05	7.39
125.5	6.84	125.4	7.12	125.2	7.47
170.3	6.91	170.2	7.17	170.0	7.59
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.30	8.58	2.30	8.58	2.52	8.82
55.13	8.39	55.13	8.39	55.28	8.67
77.93	8.36	77.93	8.36	78.08	8.65
126.1	8.33	126.1	8.33	126.2	8.61
170.9	8.29	170.9	8.29	171.0	8.59
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.83	10.04	.73	10.07	.63	10.09
53.53	9.70	53.37	9.72	53.20	9.79
76.33	9.67	76.17	9.71	76.00	9.75
124.5	9.62	124.3	9.68	124.1	9.72
169.3	9.59	169.1	9.66	169.0	9.70

Table 41.--Variation of pH with reaction time for different combinations of initial pH and initial free-chlorine concentration, New Orleans, La., March 25, 1992

[CL, initial free-chlorine concentration; mg/L, milligram per liter]

CL = 15.0 mg/L		CL = 30.0 mg/L		CL = 50.0 mg/L	
Reaction time (hours)	pH	Reaction time (hours)	pH	Reaction time (hours)	pH
		Initial pH = 5.50			
0.00	5.50	0.00	5.50	0.00	5.50
1.42	6.70	1.30	6.88	1.20	7.31
22.70	6.71	22.52	6.82	22.35	7.34
46.35	6.80	46.17	6.87	46.00	7.47
71.78	6.95	71.60	6.90	71.43	7.59
120.0	7.04	119.8	6.96	119.6	7.76
170.3	7.16	170.1	7.09	170.0	7.90
		Initial pH = 7.50			
.00	7.50	.00	7.50	.00	7.50
2.72	8.38	2.42	8.55	2.63	8.79
23.75	8.00	23.38	8.45	23.53	8.71
47.42	8.28	47.05	8.43	47.20	8.70
72.85	8.26	72.48	8.40	72.63	8.70
121.0	8.22	120.6	8.35	120.8	8.64
171.4	8.22	171.0	8.35	171.2	8.62
		Initial pH = 10.00			
.00	10.00	.00	10.00	.00	10.00
.82	10.03	.68	10.08	.60	10.11
21.65	9.91	21.45	9.89	21.30	9.96
45.32	9.82	45.12	9.81	44.97	9.88
70.75	9.77	70.55	9.77	70.40	9.83
118.9	9.69	118.7	9.71	118.5	9.78
169.2	9.67	169.0	9.67	168.9	9.74

Values of pH at the End of the Trihalomethane Formation-Potential Experiments

Values of pH at the end of the trihalomethane formation-potential experiments for each of the different combinations of initial pH and initial free-chlorine concentration are listed in table 42. These pH values differ somewhat from the pH values in tables 28-41 because they were determined on samples that had been quenched with a sodium thiosulfate solution and extracted with pentane, followed by evaporation of the pentane. Most of the small differences are believed to be from the addition of the sodium thiosulfate, which generally increased the pH values of the 5.50 and 7.50 samples and had little or no effect on the pH values of the 10.00 samples.

Dissolved Organic-Carbon and Bromide Concentrations and Specific Conductances

DOC and bromide concentrations and specific conductances for each of the water samples are listed in table 43. Replicate analyses were done for DOC for all samples except the Davenport sample. As indicated previously, three bottles of this water sample froze during storage, and formation-potential experiments were done for both the regular water sample and for the melt water recovered from the thawed frozen sample. DOC concentrations are given in table 43 for the regular water sample and for the thawed water; however, only one analysis was possible because of an insufficient quantity of water. Coefficients of variation of the replicate analyses for the other 13 samples ranged from ±0.00 to ±3.45 and averaged ±0.84 percent. Bromide concentrations ranged from less than the detection limit of 0.005 mg/L for the Quincy, St. Louis, and Ohio River water samples to 0.040 mg/L for the Missouri River water sample. An interference problem prevented the determination of the bromide concentrations for the Minneapolis, Dubuque, Davenport, and Cairo water samples.

Ultraviolet Absorbances

Ultraviolet absorbances of the natural water samples and the water samples adjusted to pH values of 5.50, 7.50, and 10.00 were measured at 254, 280, 330, and 400 nm, and the results are listed in table 44. Because three bottles of the Davenport water sample froze during storage, formation-potential experiments were done both for the regular water sample and for the melt water recovered from the thawed frozen sample. Ultraviolet absorbances are listed in table 44 for both of these water samples. The pH value of the natural water sample for each sample location is the average of the pH values for the three volumes of water used for the formation-potential experiments and the one volume used for the preparation of the THM standards. Slight precipitates were observed in the Minneapolis, LaCrosse, Dubuque, Davenport (regular and thawed), Quincy, Missouri River, St. Louis, and Cairo water samples for the pH=10.00 condition. The extent to which the UV absorbances of these samples were affected by this precipitate is unknown.

Table 42.–Values of pH at the end of the trihalomethane formation-potential experiments

[CL, initial free-chlorine concentration; mg/L, milligram per liter; NS, no sample because of insufficient water]

General location	Initial pH	CL (mg/L) 15.0	30.0	50.0
Minneapolis, Minn.	5.50	6.68	6.84	7.08
	7.50	8.12	8.29	8.64
	10.00	9.52	9.62	9.69
LaCrosse, Wis.	5.50	6.86	6.93	7.11
	7.50	8.09	8.18	8.65
	10.00	9.23	9.43	9.49
Dubuque, Iowa	5.50	7.03	7.14	7.52
	7.50	8.19	8.34	8.81
	10.00	9.33	9.49	9.60
Davenport, Iowa (regular sample)	5.50	NS	7.04	7.32
	7.50	NS	8.42	8.81
	10.00	9.38	9.48	9.62
Davenport, Iowa (thawed sample)	5.50	NS	6.98	7.26
	7.50	NS	8.42	8.83
	10.00	NS	9.53	9.63
Quincy, Ill.	5.50	7.15	7.26	7.52
	7.50	8.32	8.33	8.83
	10.00	9.45	9.56	9.66
Missouri River near confluence with Mississippi River	5.50	6.97	7.10	7.41
	7.50	8.12	8.32	8.66
	10.00	9.21	9.37	9.65
St. Louis, Mo.	5.50	7.19	7.33	7.75
	7.50	8.47	8.50	8.91
	10.00	9.48	9.59	9.68
Cairo, Ill.	5.50	6.82	6.96	7.39
	7.50	8.29	8.54	8.97
	10.00	9.50	9.61	9.74
Ohio River near confluence with Mississippi River	5.50	7.17	7.54	8.37
	7.50	8.39	8.96	9.26
	10.00	9.44	9.58	9.71

Table 42.--Values of pH at the end of the trihalomethane formation-potential experiments --Continued

General location	Initial pH	CL (mg/L)		
		15.0	30.0	50.0
Memphis, Tenn.	5.50	7.13	7.28	7.82
	7.50	8.36	8.76	9.19
	10.00	9.48	9.66	9.78
Greenville, Miss.	5.50	6.67	6.99	7.50
	7.50	8.22	8.66	9.03
	10.00	9.50	9.66	9.75
Natchez, Miss.	5.50	7.07	7.28	8.00
	7.50	8.31	8.72	9.04
	10.00	9.40	9.65	9.76
Baton Rouge, La.	5.50	7.02	7.31	8.12
	7.50	8.50	8.87	9.23
	10.00	9.63	9.74	9.85
New Orleans, La.	5.50	6.99	7.24	7.87
	7.50	8.33	8.74	9.05
	10.00	9.41	9.60	9.76

Table 43.--Dissolved organic-carbon and bromide concentrations and specific conductances of the water samples

[DOC, dissolved organic carbon; Br, bromide; Rep 1, replicate number 1; Rep 2, replicate number 2; mg/L, milligram per liter; μS/cm, microsiemens per centimeter at 25 degrees Celsius; ND, not detected; IF, interference problem; NS, no sample because of insufficient water]

General location	Concentration			Specific conductance (μS/cm)
	DOC		Br (mg/L)	
	Rep 1 (mg/L)	Rep 2 (mg/L)		
Minneapolis, Minn.	9.3	9.4	IF	402
LaCrosse, Wis.	7.2	7.3	0.010	495
Dubuque, Iowa	6.9	6.8	IF	407
Davenport, Iowa (regular sample)	6.4	NS	IF	422
Davenport, Iowa (thawed sample)	6.0	NS	IF	388
Quincy, Ill.	4.7	4.7	ND	496
Missouri River[1]	4.3	4.2	.040	530
St. Louis, Mo.	4.2	4.5	ND	495
Cairo, Ill.	4.8	4.7	IF	478
Ohio River[1]	2.2	2.2	ND	275
Memphis, Tenn.	3.5	3.5	.011	348
Greenville, Miss.	3.2	3.3	.010	340
Natchez, Miss.	2.9	2.8	.016	312
Baton Rouge, La.	3.0	3.0	.014	309
New Orleans, La.	2.8	2.8	.030	333

[1] Sampling site 1.6 kilometers upstream from confluence with Mississippi River.

Table 44.--Ultraviolet absorbances of the water samples

[nm, nanometer]

General location	pH	Ultraviolet absorbance, in absorbance units, at wavelengths			
		254 (nm)	280 (nm)	330 (nm)	400 (nm)
Minneapolis, Minn.	8.02	1.356	0.981	0.424	0.122
	5.50	1.344	.970	.405	.109
	7.50	1.341	.968	.414	.155
	10.00	1.289	.948	.459	.218
LaCrosse, Wis.	8.04	1.101	.806	.359	.107
	5.50	1.076	.786	.336	.092
	7.50	1.111	.815	.360	.104
	10.00	1.028	.809	.413	.203
Dubuque, Iowa	8.06	1.084	.811	.371	.121
	5.50	1.026	.759	.337	.099
	7.50	1.031	.764	.346	.105
	10.00	.942	.700	.320	.103
Davenport, Iowa (regular sample)	8.10	.954	.703	.313	.093
	5.50	.946	.696	.301	.086
	7.50	.974	.721	.319	.095
	10.00	.878	.636	.279	.077
Davenport, Iowa (thawed sample)	8.14	.933	.692	.312	.097
	5.50	.926	.687	.302	.090
	7.50	.929	.690	.308	.096
	10.00	.928	.656	.299	.101
Quincy, Ill.	8.16	.723	.529	.228	.066
	5.50	.723	.528	.221	.058
	7.50	.735	.541	.231	.066
	10.00	.693	.534	.274	.139
Missouri River near confluence with Mississippi River	7.95	.610	.451		.059
	5.50	.602	.441	.191	.054
	7.50	.605	.445	.198	.059
	10.00	.551	.398	.174	.050

Table 44.--Ultraviolet absorbances of the water samples --Continued

General location	pH	Ultraviolet absorbance, in absorbance units, at wavelengths			
		254 (nm)	280 (nm)	330 (nm)	400 (nm)
St. Louis, Mo.	7.98	.668	.491	.213	.062
	5.50	.671	.491	.208	.056
	7.50	.679	.498	.216	.063
	10.00	.599	.437	.191	.059
Cairo, Ill.	7.98	.709	.519	.224	.064
	5.50	.703	.513	.214	.054
	7.50	.707	.519	.222	.064
	10.00	.673	.494	.219	.071
Ohio River near confluence with Mississippi River	7.76	.349	.262	.114	.034
	5.50	.345	.256	.111	.031
	7.50	.345	.258	.116	.033
	10.00	.357	.270	.124	.041
Memphis, Tenn.	7.80	.506	.378	.168	.050
	5.50	.505	.372	.162	.046
	7.50	.507	.379	.168	.049
	10.00	.515	.386	.180	.058
Greenville, Miss.	7.82	.481	.356	.158	.048
	5.50	.481	.354	.152	.043
	7.50	.480	.355	.156	.046
	10.00	.493	.366	.169	.055
Natchez, Miss.	7.85	.476	.355	.157	.049
	5.50	.476	.353	.152	.044
	7.50	.479	.358	.157	.049
	10.00	.496	.372	.173	.059
Baton Rouge, La.	7.82	.459	.343	.153	.044
	5.50	.461	.343	.150	.041
	7.50	.464	.349	.156	.046
	10.00	.474	.357	.165	.053

Table 44.–Ultraviolet absorbances of the water samples –Continued

General location	pH	Ultraviolet absorbance, in absorbance units, at wavelengths			
		254 (nm)	280 (nm)	330 (nm)	400 (nm)
New Orleans, La.	7.78	.409	.301	.131	.038
	5.50	.407	.297	.126	.034
	7.50	.411	.303	.132	.039
	10.00	.415	.308	.139	.043

Error Analysis

The coefficient of variation normalized with respect to the mean concentration and expressed as a percentage was used to indicate reproducibility between duplicate samples. This coefficient of variation was computed from

$$C_v = \pm\{[C_1^2 + C_2^2 - (C_1 + C_2)^2/2]/2\}^{0.5}\, 100/C_{12} \qquad (1)$$

where

C_v is the coefficient of variation;

C_1 is concentration number 1;

C_2 is concentration number 2; and

C_{12} is the mean of concentrations 1 and 2.

Values of the coefficients of variation for the analysis of duplicate THM samples and NPTOX samples are summarized in table 45. Minimum, maximum, and mean values of the coefficient of variation together with the number of pairs of values in each comparison are listed.

Table 45.--Minimum, maximum, and mean values of the coefficient of variation for analysis of duplicate trihalomethane and nonpurgeable total organic-halide samples

[THM, trihalomethane; NPTOX, nonpurgeable total organic halide]

Sample type	Number of pairs	Coefficient of variation, in percent		
		Minimum	Maximum	Mean
THM	130	±0.00	±4.75	±0.79
NPTOX	130	±.00	±6.45	±1.83

REFERENCES CITED

Bellar, T.A., Lichtenberg, J.J., and Kroner, R.C., 1974, The occurrence of organohalides in chlorinated drinking waters: Journal of American Water Works Association, v. 66, no. 12, p. 703–706.

Buffle, J., Deladoey, P., and Haerdi, W., 1978, The use of ultrafiltration for the separation and fractionation of organic ligands in fresh waters: Analytica Chimica Acta, v. 101, no. 2, p. 339–357.

Ceraso, Jane, 1987, Development of a surrogate parameter to determine the trihalomethane formation potential of two reservoirs: Journal of New England Water Works Association, v. 101, no. 4, p. 382–400.

Chadick, P.A., and Amy, G.L., 1987, Coagulation and adsorption of humic substances—An analysis of surrogate parameters for predicting effects of trihalomethane formation potential: Environmental Technology Letters, v. 8, p. 261–268.

Edzwald, J.K., Becker, W.C.,and Wattier, K.L., 1985, Surrogate parameters for monitoring organic matter and THM precursors: Journal of American Water Works Association, v. 77, no. 4, p. 122–132.

Federal Register, 1979, Analysis of trihalomethanes in drinking water, v. 44, no. 231, p. 68672–68690.

Fishman, M.J., and Friedman, L.C., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations Report, book 5, chap. A1, 545 p.

Fleischacker, S.J., and Randtke, S.J., 1983, Formation of organic chlorine in public water supplies: Journal of American Water Works Association, v. 75, no. 3, p. 132–138.

Johnson, J.D., and Jensen, J.N., 1986, THM and TOX formation—Routes, rates, and precursors: Journal of American Water Works Association, v. 78, no. 4, p. 156–162.

Moody, J.A., in press, Chapter 1--Introduction, in Moody, J.A., editor, Chemical data for water samples collected druing four upriver cruises on the Mississippi River between New Orleans, Louisiana, and Minneapolis, Minnesota, May 1990-April 1992: U.S. Geological Survey Open-File Report 94-523.

Moore, T.R., 1987, Assessment of a simple spectrophotometric method for the determination of dissolved organic carbon in freshwaters: New Zealand Journal of Marine and Freshwater Research, v. 21, no. 4, p. 585–589.

Oliver, B.G., and Thurman, E.M., 1981, Influence of aquatic humic substances on trihalomethane potential, in Proceedings, Fourth Conference on Water Chlorination, October 18–23, 1981, Environmental Impact and Health Effects: Ann Arbor, Mich., Ann Arbor Science Publishers, p. 231–241.

Rook, J.J., 1974, Formation of haloforms during chlorination of natural waters: Water Treatment and Examination, v. 23, no. 2, p. 234–243.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., 1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A3, 80 p.

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